Catalytic Converter Made of Non-noble Material for an Automobile

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Abstract—This paper is reports on the review of catalytic converter made of non - noble material for an automobile. The converter made of the noble material is highly efficient but there is some major problem associated with these converters. First problem is the cost of the catalytic converter increased due to high cost of the noble material. Second problem is that they are operated at the higher temperature. Third problem is that the noble material is rarely available in earth crust and hence they are exhausted one day. Due to above problem associated with the noble material there is some option required for the noble material which is easily available at the lower cost. The non – noble material (Copper, Nickel, Zinc etc.) is perfect for the use into the catalytic converter instead of the noble material as they are easily available at low cost and operated at lower temperature than the noble material.

Key words: catalytic converter, non-noble material

I. INTRODUCTION

Catalytic converter is used to reduce the exhaust gas emission from the internal combustion engine. In internal combustion engine the time required for the combustion and other process are much less at higher speed and hence cause the incomplete combustion of the fuel. This lead to the production of the hydrocarbons (HC), nitrogen oxides (NOx) and carbon monoxide (CO) into the engine cylinder. These emissions are particularly high during the idling and deceleration; when insufficient air is take in for complete combustion to occur.

Carbon monoxide is a product of a partial combustion of hydrocarbon in fuel. It is always present when there is a lack of the oxygen during the combustion and thus directly dependent on the applied engine air/fuel ratio. There are several paths that cause hydrocarbons in the exhaust. The most obvious is, as in the cause of CO, a lack of oxygen when the air/fuel mixture is rich. NOx is formed during combustion in the engine when oxygen reacts with nitrogen because of a high combustion temperature.

Into the catalytic converter the catalytic material such as platinum, rhodium, gold etc. are conventionally used are highly chemically reactive with the exhaust gas emissions at high temperature. In catalytic converter there is main two different types of the catalyst at work, a reduction catalyst, usually made of noble material. This type of structure causes the expose the maximum surface area of catalyst to the exhaust stream.

The reduction catalyst uses platinum and rhodium to help reduce the NOx emissions. When NO or NO2 molecule contacts the catalyst, the catalyst rips the nitrogen atom out of the molecule and holds on to it, freeing the oxygen in the form of O2. The nitrogen atoms bond with other nitrogen atoms that are also struck to the catalyst, forming N_2. For example:

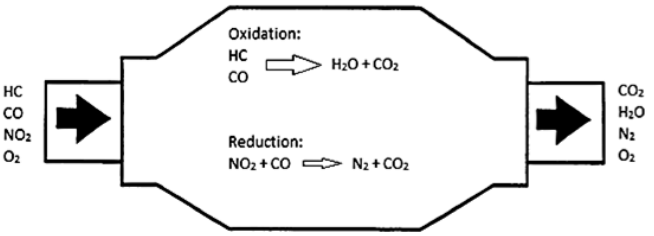

Fig. 1: [Three way catalytic converter chemical process] [2]

$$2NO \longrightarrow N_2 + O_2$$

Or

$$2NO_2 \longrightarrow N_2 + 2O_2$$

The oxidation catalyst is the second stage of the catalytic converter. It reduces the unburned hydrocarbons and carbon monoxide by burning them over a platinum and palladium catalyst. This catalyst aids the reaction of the CO and hydrocarbons with the remaining oxygen in the exhaust gas. For example:

$$2CO + O_2 \longrightarrow 2CO_2$$

$$HC + O_2 \longrightarrow CO_2 + H_2O$$

There are two types of structures used into the catalytic converter – honeycomb and ceramic beads. Most cars today use a honeycomb structure. The main problem associated with the usage of noble material into the catalytic converter is as follows:

1) Noble materials are rarely available into earth crust and exhausted one day.
2) The cost of extraction of noble material from the earth crust is high and hence causes overall increase the cost of the catalytic converter.
3) The operating temperature of the catalytic converter made of noble material is very high compare to the non-noble material.

Due to above major problem associated with the use of the noble material into catalytic converter it is necessary to use non-noble material into catalytic converter due to following advantages:

1) The non-noble materials are easily available on to the earth.
2) The cost of non-noble material is very less compared to the noble material and catalytic converter can be made at very low cost.
3) The operating temperature of the catalytic converter made of non-noble material is low compared to the noble material.

Catalytic converter just used behind the engine manifold to reduce the heat-up time has been practiced. Electrically heated catalysts are used to overcome the cold temperature during the start-up & provide heat to the exhaust gas or the catalytic surface using resistive materials and a current/voltage source.

II. BACKGROUND OF THE INVENTION

During the background study of the catalytic converter made of non-noble material following papers are reviewed connected to the subject of: catalytic converter made of non-noble material and catalytic converter holding and making methods.

Ren Wang, Shanling Wu and Zhigang Zhang [1] do research on to Non-precious metal three ways catalyst aimed to reduce the cost of catalytic converter. In their non-precious metal three-way catalyst which reduces hydrocarbon, carbon monoxide and nitrogen oxide from internal combustion engine exhaust and industrial emissions, with a conversion capability comparable to the conversion efficiencies of current precious metal catalysts, and with superior NOx conversion characteristics and durable when operated under prolonged high temperature conditions.

Chirag Amin, Pravin P. Rathod and Jigish J. Goswami [2] made research onto the exhaust analysis of four stroke single cylinder diesel engine using copper based catalytic converter. In which they describe the method of the making of catalytic converter and also shows advantages and requirement of the copper based catalytic converter against recently used noble material catalytic converter.

Richard P. Merry [3] shows the method of making a catalytic converter or diesel particulate filter. In which he provides a catalytic converter and a particular filter with a flexible metal reinforced intumescent mounting composite which exerts a low temperature volume stress of at least 20 kpa and a high temperature volume stress of less than 500 kpa.

Other papers which are related to the research and which are used to improve the research as follow: Richard C. Comelison [4] shows the method of housing for catalytic converter element. Markus Gloeckle and Martin Bohnet [5] gave research paper on catalytic converter assembly in an exhaust gas post treatment system. Ta-Jen Huang [6] uses the electrochemical catalytic converter for exhaust emission control. Yoshihide Segawa [7] gave paper on to the automobile exhaust gas catalytic converter. J. Robota Heinz and Karl C. C. Kharas [8] gave patent on to the catalytic converter having a catalyst with noble metal on molecular sieve crystal surface and methods of making same. Georges Bouraad and Denis Laurent [9] gave patent on to the method for assembling a catalytic converter. Mark Anderton Criddle [10] shows the internal combustion engine with catalytic converter. Di-Jia Liu, Peter M. Michalakos and Robert Tom [11] gave patent about catalytic converter for removing ozone having un-anodized and wash coat layers for easy journey of passengers in the plane. William Mickelson, Ying-Lan Chang, Craig Bryant and Bradley N. Johnson [12] made a high efficiency, low loss NO to NO2 catalytic converter. Richard P. Merry [13] of Minnesota mininig and manufacturing company gave patent on to catalytic converter, particulate filter for exhaust systems. William Whittenberger [14] made a composite catalytic converter patent. Paul D. and Gary F. [15] show the catalytic converter and diesel particulate filter. Stephan Thomas and George Ronald [16] made catalytic converter with metal monolith having an integral catalyst. Senta Tojo, Hiroshi Mori and Katumi Okai [17] gave patent onto the ceramic catalytic converter which is now a day mostly used into the cars today. Naoyuki Kobayashi, Estuo Kosaka and Kazuo Tanigawa [18] show the methods of manufacturing a catalytic converter.

Based on to above researches we see that there is a highly usage of the noble material into catalytic converter and cause overall increase into the cost of the catalytic converter. From above review we see that there is some options are available instead of using noble metal into catalytic converter such as non-noble material and ceramics structures.

III. METHOD OF MAKING CATALYTIC CONVERTER

For making of the catalytic converter we required one housing for catalytic converter and copper net of smaller grain size. Now first of all we have to take the housing and open it by cutting it from one side. Then the inside material of the housing is removed and cleared it for proper mounting of the copper sieves which are cut according to the size of the catalytic converter size. The dimension of the catalytic converter is measured with the proper instrument and marked on to some card board. The card board is then cut according to that marking and the copper sieves are then cut as the shape of the housing of the catalytic converter. The copper sieves are then taken into 8 to 10 cut piece of the copper net and bound into the bunch of the copper sieves as per the grain size of the copper sieves. Now this bunch of the copper sieve is arranged into the catalytic converter housing with proper type of the holding methods of the copper sieves bunch. Here we have to take care of the copper sieve bunch that it does not goes out from its setting during the adjusting it into the catalytic converter housing. After that we properly weld the housing by gas welding and smoothing the welding surface.

IV. CATALYTIC CONVERTER TESTING AND RESULT

Without Catalytic Converter					
Load (kg)	CO (g/km)	CO_2 (g/km)	NO_X (ppm)	HC (g/km)	O_2 (g/km)
0	0.160	1.6	550	31.0	17.98
1.5	0.100	1.9	666	29.0	17.71
3.0	0.080	2.1	799	25.0	17.45
5.0	0.068	2.3	999	23.0	17.16
With Catalytic Converter					
Load (kg)	CO (g/km)	CO_2 (g/km)	NO_X (ppm)	HC (g/km)	O_2 (g/km)
0	0.060	1.8	440	21.0	18.33
1.5	0.050	2.1	552	18.0	17.94
3.0	0.043	2.4	648	16.0	17.82
5.0	0.034	2.7	789	14.0	17.65

Table. 1: Testing Results

During the testing of the catalytic converter there is two times the test is carried out at the same operating conditions but with and without the catalytic converter.

First of all the testing of the diesel engine exhaust gases with the different loading conditions and without the catalytic converter is carried out and results for that is observed. After that, same as above the testing of the engine exhausts gases with the catalytic converter is carried out and the result is observed. The result obtained from the above is as given as in tables:

Now as from the above table we can clearly see that the amount of the Carbon Monoxide (CO), Nitrogen Oxides (NOX) and Hydrocarbons (HC) is reduced with the use of the catalytic converter made of non-noble material. The amount of the Carbon monoxide reduction is about 50 – 62% whereas the reduction into the Nitrogen Oxides is about 20 – 27% and the reduction into the Hydrocarbons is about 35 – 40% by the use of the catalytic converter made of the non-noble material.

V. CONCLUSION

Though non-noble metal, copper works as a catalyst for the conversion of pollutants in exhaust but in a limited proportion. Although the non-noble material based catalytic converter conversion efficiency increased by the providing heating to the catalytic converter by small amount of the electric supply from the battery of the automobile. The catalytic converter made of the non-noble material has significant advantages such as a less cost than the catalytic converter made of the noble material and lower operating temperature than the noble metal and also easily availability of the non-noble material. By increasing the population on to the earth leads to increase the number of the automobile on to the earth and leads to increase into the pollution. By the non-availability of the noble material, the non-noble material catalytic converter are the best option for the reducing the pollution.

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